Measurement of Risk Efficiency on the Field o Rice Cultivation in Bangladesh: A Data Envelopment Framework

Kanis Fatama Ferdushi[1+], Anton Abdulbasah Kamil[1], Adli Mustafa[1] and Md Azizul Baten[2]

[1]School of Distance Education, Universiti Sains Malaysia

[2]School of Quantative Sciences, University Utara Malaysia

Abstract. The endeavor of this paper is to investigate variability of yield under Data Envelopment Analysis. Panel data were taken for this framework from 1980-2008 in the agricultural field of Bangladesh concentrated on seasonal rice crop like as Aus, Aman, and Boro .This analysis was carried to find variability of yield for different environmental risk as like for Rainfall, Temperature and also for Humidity of seasonal rice yield. Using this yield variability which is called as a production risk, presented a method of Risk minimization under Data Envelopment Analysis. For Aman Season (wet season), allocative efficiency was 77% and Risk efficiency was also equal to allocative efficiency because technical efficiency came out 100% . The results of Boro season (dry season) indicated that, mean allocative efficiency was 82.9% and risk efficiency was 82.9 % .From this results it can be concluded that risk inefficiency is due to heavy rainfall, droughtness and disproportionate humidity.

Keywords: Data Envelopment Analysis, Risk Efficiency, Inefficiency.

1. Introduction

As non-parametric method, the Data Envelopment Analysis model becomes very well-accepted model in different applied cases.DEA is originally presented in (Charnes, Cooper, Rhodes 1978), based on the earlier work of (Farrell 1957). They proposed a model which had an input orientation and assumed constant returns to scale (CRS) and later (Banker, Charnes ,Cooper 1984) proposed a variable returns to scale (VRS) model. In a (Just-Pope 1978 and 1979) framework risk analysis involves recovering the residuals and using them to investigate the marginal effects of inputs on production risk, or noise. Firstly, (Just and Pope 1978) framework of risk efficiency is introduced. Secondly, the production risk is minimized through the data envelopment model. This risk efficiency will reveal that a farm can increase their yield with the minimization of risk.

Bangladesh has a tropical monsoon season characterized by extensive seasonal variations in rainfall, high temperatures, and high humidity. Three types of principal rice exist in Bangladesh. Boro rice is grown completely under the irrigated ecosystem during the dry period (November to July) while Transplanted Aman (during July to December), Transplanted Aus (during April to August) are grown under the rain fed ecosystem. Climate change is likely to result in more weather extremes, with water deficits and floods becoming more frequent (Wassmann et al 2009). In rain fed areas, flood is the most severe constraint that reduces yield. In dry season, drought also affects the production of millions of hectares in irrigated areas. In the future water deficit is predicted to be a major challenge for sustainable rice production. Another major source of uncertainty, higher temperature drought incidence could reduce global rice yield by 12-14% by 2050 (Wassmann et al 2009). This research will apply a non-parametric approach DEA of risk minimization to measure production risk efficiency of selected rice yield in Bangladesh. We will estimate how much variability can be reduced and accelerate production by the farm to gain a sustainable yield. According to (Berg 2010) if a farm can produce a certain level of output utilizing specific input levels, another farm of equal scale should be capable of doing the same.

Every farm faces same production variability but some can minimize that variability according to their expectation.

1.1. Objectives

[+] Corresponding Author.Kanis Fatama Ferdushi;Tel:+60164962685.
Email Address:ferdushi_nafia@yahoo.com

The commonly followed objectives of this analysis

- High rice yield with minimized cost
- Identify the causes behind that do not minimize risk on rice
- Encounter Reduced variability
- Find risk efficiency of Rice crop (Aus ,Aman, Boro)

1.2. Data and Materials

The data on rice production in Bangladesh are obtained from the year book agricultural statistics of Bangladesh published by the Bangladesh Bureau of Statistics (BBS). Data are collected depends on three principal rice crops, Aus, Aman and Boro. Dependent variable is rice yield and independent variable is climate variable; such as rainfall, temperature and humidity. For this study we consider 28 year from -1980-2008. A detail of data set has been included in appendix.

2. Methodology

1st Step: According to Just and Pope; 1978, 1979, we followed stochastic production functions with heteroscedastic error term.

$$Y_{it} = f\left(x_{1it}, x_{2it}, \ldots, x_{Nit}; \alpha\right) + e_i \quad (1)$$

$$\hat{e}_i = Y_{it} - f\left(x_{1it}, x_{2it}, \ldots, x_{Nit}; \hat{\alpha}\right) \quad (2)$$

$$\hat{e}_i^2 = \left[Y_{it} - f\left(x_{1it}, x_{2it}, \ldots, x_{Nit}, \hat{\alpha}\right)\right]^2 \quad (3)$$

2nd Step: Risk Minimization

$$\begin{aligned} &\underset{\lambda, R_i^*}{Min}\ G_i' R_i^* \\ &-y_i + Y\lambda \geq 0 \\ &R_i^* - R\lambda \geq 0 \\ &\lambda \geq 0 \end{aligned}$$

If G_i is a vector of yield variability or production risk for the i-th DMU; R_i^* is the Risk minimization vector of input quantities for the i-th DMU; y_i is the output levels; R-is a vector of environmental risk factor affecting Rice yield variability. In this study we have used software DEAP 2.1 (Coelli, 1996).

Risk Efficiency $RE = \dfrac{G_i' R_i^*}{G_i' R_i}$

Allocative Efficiency $AE = \dfrac{RE}{TE}$

3. Results and Discussion

3.1. Area Covered by Crops of Rice

In Bangladesh the major cereal crops are rice, with 79.4 percent of the total cultivatable land area under rice crop, as mentioned in (FAO/WFP CFSAM 2008) Report. Fig. 1 shows that the Aus crop with 10 percent of area, the rain fed Aman crop with about 51 percent area and irrigated Boro crop with about 39 percent of the cropped area.

3.2. Yield Produce by Rice Crops

Aman rice yield in 2007/08 was 1.91 tons/ha, a decrease of 4.4 percent below the national yield for the previous year of 2.0 tons/ha. Aman production during 2007-08 suffered from serious hold up due to two rounds of floods and a devastating cyclone Sidr in 2007. The national average Boro rice yield of 3.86 tons/ha, an increase of 10 percent above the national yield for the previous year of 3.52 tons/ha. Fig. 2 shows although Aman rice covers most of the area but could not produce highest amount of yield due to facing production risk which is higher than another season.

3.3. Estimation of Production Risk

Boro production is minimizing maximum production variability stated in table 1. Boro season does not face higher rainfall during production process. Boro yield is irrigated by farmers. Aman faces excess rainfalls sometimes submerge all area. Sometimes Farmers do not want to pick up their harvested crops due to lose profit.

4. Conclusion

Every farm faces production variability during their production process for different cases such as heavy rainfall or sometimes droughtness. Boro rice is cultivated by the irrigated systems and does face less production risk and can minimize more production risk. Rain fed rice Aman faces uneven distribution of rainfall during the monsoon month and for submerging due to excess rainfall proper establishment of seedling is impossible. This type of environment is favourable for pest .Those types of problems limit the yield of rain fed rice Aman and also cannot produce minimum risk. In rice cropping time needs to be become concern for those days of submerge. Further research will be carried out with the tobit regression model to examine the impact of rainfall, temperature and humidity.

5. Acknowledgements

The authors gratefully acknowledge the contributions of Postgraduate Research Grant Scheme (PRGS) of Universiti Sains Malaysia, Account No. 1001/PJJAUH/844109 for their grant.

6. References

[1] Berg, S.,. Water Utility Benchmarking: Measurement, Methodology, and Performance Incentives. *International Water Association*, 2010.

[2] BBS (Bangladesh Bureau of Statistics). *Statistical Yearbook of Bangladesh.*BBS,Dhaka, 1980-2008.

[3] FAO/WFP CFSAM.FAO/WFP crop and food supply assessment mission to Bangladesh. *Food and Agricultural Organization of the United Nations* , World Food Program, Rome.

[4] R. Wassmann, S. V. K. Jagadish, S. Heuer. Climate change affecting rice production : The Phycological and Agronomic Basis for possible adaptation strategies. *In Donald L. Sparks, editor, Advances in Agronomy.*2009,101: Burlington: Academic Press.

[5] T. Coelli. A guide to DEAP version 2.1: A Data Envelopment Analysis(Computer) Program, *CEPA Working Paper 96/08.*1996,University of New England, Australia.

[6] R.D. Pope, and R.A. Kramer. Production Uncertainty and Factor Demands for the Competitive Firm. *Southern Economic Journal* . 1979,PP.46, 489-501.

[7] R. E. Just, and R. D. Pope. Stochastic Specification of Production Functions and Economic Implications. *Journal of Econometrics.* 1978, 7: PP. 67–86.

[8] A.Charnes, W.W.Cooper, E.Rhodes. Measuring the efficiency of decision making units. *European Journal of operation research.*1984, 2(6):PP.429-444.

[9] R.D. Banker, A. Charnes, W. W. Cooper . Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management Science*. 1984, 30(9): PP.1078-1092.

[10] M.J. Farrell. Convexity assumption in theory of competitive markets. *Journal of Political Economy*. 1959, 67:PP. 377-391.

Table 1: Technical, Allocative and Risk efficiency estimates of rice crop in Bangladesh during 1980-2008

Crop	Technical Efficiency	Allocative Efficiency	Risk Efficiency
Rice –Aus	**1**	**1**	**1**
Rice-Aman	**1**	**.770**	**.770**
Rice-Boro	**1**	**.829**	**.829**

Graph for Area

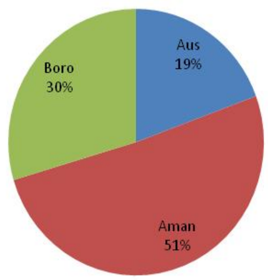

Figure 1: Yield Shares in Total Area Surveyed 2009.

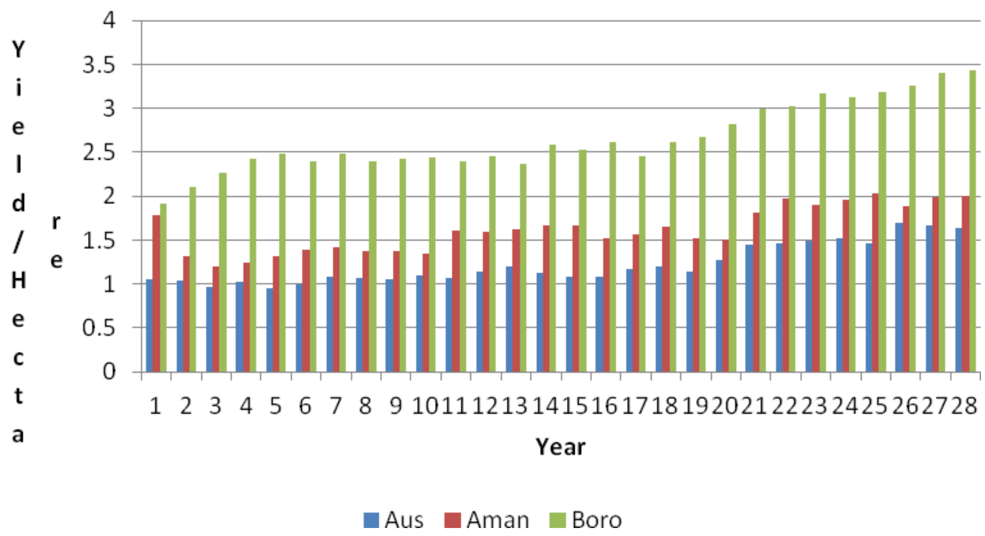

Figure 2: Three types of crop yield from 1980-2008 respectively.

Appendix:
Dependent Variable
Yield: Yield is measured by metric tons per hectare.
Climate Variables
Rainfall

Total rainfall faces by Boro rice during February-July session. Similarly during Aus and Aman season rice has total rainfall throughout month from March-June and July-December respectively. Rainfall is calculated by millimeter. The annual rainfall is about 1600 mm; most parts of the country receive at least 2000 mm per year. Most of the rain (often over 60 inches per year) falls occurs during the rainy monsoon season (June to Sep). Very little rain falls in the cooler month (Nov-Feb).

Temperature

Maximum summer temperature range between 30^0C to 40^0C.April is the warmest month in most parts of the country 34^0C. January is the coldest month, when the average temperature for most of the country is about 10^0C. Here the average monthly temperature is in Celsius in each rice session.

Humidity

Humidity is an important measure in agriculture because it has an effect on evaporation rates. Where there is high humidity, animals may get stressed, and moulds, mildews and fungus may grow which is indirectly effect in agriculture especially in rice production. For this research average humidity is in percentage in each crop.